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# Morphing structures for flow regulation

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Morphing structures have the capability of responding to external environment variations by adapting and reconfiguring their shape. For this reason, morphing structures are a promising concept for improving structural efficiencies in aerospace and automotive applications. The utilisation of conventional mechanisms, which are composed of several connected elements driven by heavy actuators to obtain geometry variations, usually makes the structure much heavier. Passively morphing structures, on the other hand, allow much lighter and more flexible systems as they remove the need for a separate actuator.

This study shows a promising concept of a mono- and bi-stable structure for a wide spectrum of applications including arterial flow control, passive flow control over airfoils and even novel household appliances. In particular, a morphing air duct has been designed by taking advantage of multistable capabilities, which were investigated by studying the post buckling behaviour of the cover of the air duct.

A parametric Finite Element Analysis (FEA) of the bifurcation behaviour of a 1D beam under different edge conditions was carried out in the ABAQUS software package. The boundary conditions were altered parametrically to study the effect on the final buckled shape and on the “snap-through” behaviour. Multistability was fully controlled by analysing the influence of parameters, such as end rotations, pre-stress, stiffness variation and vertical displacement of the structure extremities. In this way, it was possible to optimize the design of the mono- or bi-stable morphing beam, which was then extended to the three dimensional device.

Daynes et al. (2011) have recently developed a bistable morphing air intake, characterised by open and closed stable states, which can be achieved by means of a mechanical actuator. The air intake adapts to different aerodynamic profiles during different flight conditions. Multistability was obtained by applying pre-stress and varying the stiffness over the structure length.

The novelty of the present work is designing a device that is able to snap between different configurations without the use of a mechanical actuator. To this aim, a Fluid-Structure Interaction (FSI) study on bi- and mono-stable structures showed the possibility of achieving a morphing air intake that may switch between its open and closed states by means of the interaction with the external environmental conditions, and more specifically, with the pressure conditions caused by the fluid flowing over the structure.

